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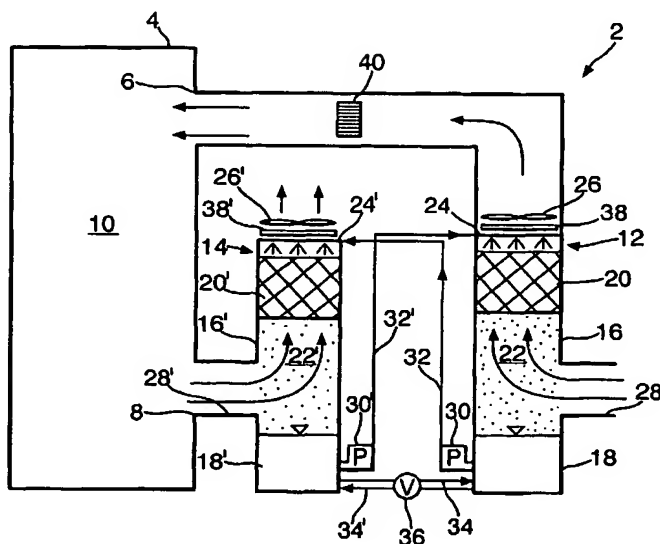
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(54) Title: AIR CONDITIONING SYSTEM AND METHODS



(57) Abstract: An air conditioning system for conditioning the space within an enclosure having at least one inlet and one outlet, the system comprising first and second liquid/air heat exchangers; the first heat exchanger having an opening for receiving fresh air from the environment and for propelling the fresh air through the first heat exchanger to exchange heat with the liquid before it is entered into the enclosure, and the second heat exchanger having an opening for receiving air from the enclosure and for propelling it through the second heat exchanger to exchange heat with the liquid before it is expelled into the atmosphere. There are also provided methods for air-conditioning an enclosed space and for evaporation of industrial wastes.

## **AIR CONDITIONING SYSTEM AND METHODS**

### **Field of the Invention**

The present invention relates to air conditioning systems and methods. More specifically, the invention relates to fresh air conditioning systems and methods for both summer and winter use.

### **Background of the Invention**

Modern homes require air conditioning, specifically, cooling in summer and heating in winter. The flow of fresh air is also necessary, in order to remove unwanted gases and odors. When the enthalpy gradient between outside and inside air is large, the flow of fresh air associated with energy consumption, for cooling in summer and heating in winter, increases. Thus, in tropical climates, where the outside air enthalpy is 90 kJ/kg and inside air is kept at 52 kJ/kg, the flow of fresh air required to exchange 1 kg of air increases the latent load by 38 kJ. Similarly, in the winter, the exchange of fresh air increases the heating load.

### **Disclosure of the Invention**

It is thus a broad object of the present invention to provide systems and methods for fresh air conditioning of a space within an enclosure, utilizing heat and liquid exchange between fresh air flowing into the system and air exiting from the enclosure.

In accordance with the invention, there is provided an air conditioning system for conditioning the space within an enclosure having at least one inlet and one outlet, said system comprising first and second liquid/air heat exchangers; said first heat exchanger having an opening for receiving fresh air from the environment and for propelling the fresh air through said first heat exchanger to exchange heat with the liquid before it is entered into said enclosure, and said second heat exchanger having an opening for receiving air from the enclosure and for propelling it through said second heat exchanger to exchange heat with the liquid before it is expelled into the atmosphere.

The invention further provides a method for air-conditioning an enclosed space, comprising providing an air-conditioning system according to the present invention, and

precooling said liquid prior to entering same into the evaporator by utilizing cooled air from said space.

The invention still further provides a method for air-conditioning an enclosed space, comprising providing an air-conditioning system according to the present invention, and utilizing the heat pump for preconditioning the liquid passing therethrough before propelling the liquid through said heat exchangers.

The method still further provides a method for evaporation of industrial wastes according to the present invention; replenishing the reservoir of the heat exchanger receiving fresh air from the environment with liquid desiccant, and draining excess water from the reservoir of the other heat exchanger.

#### **Brief Description of the Drawings**

The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures, so that it may be more fully understood.

With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

In the drawings:

Fig. 1 is a schematic, cross-sectional view of an air conditioning system according to the present invention;

Figs. 2 and 3 are schematic, cross-sectional views of the system of Fig. 1, including a heat pump illustrating two possible operation modes of the system during summer conditions,

Figs. 4 and 5 are schematic, cross-sectional views of the system of Fig. 1, including a heat pump illustrating two possible operation modes of the system during winter conditions;

Fig. 6 is a schematic, cross-sectional view of the system according to the present invention, for industrial waste evaporation, and

Fig. 7 is a schematic, cross-sectional view of the system according to the present invention for utilizing a multi-way valve, enabling summer and winter operations.

### **Detailed Description of Preferred Embodiments**

Illustrated in Fig. 1 is a preferred embodiment of the present invention, of a system 2 for air conditioning an enclosure during both summer and winter. It should be noted, however, that with minor modifications that will become apparent hereinafter, the system can be utilized for air conditioning during summer or winter, as required.

Shown in Fig. 1 is an enclosure 4, having an air conditioning inlet opening 6 and an air conditioning outlet opening 8 and defining an air-conditioned space 10. System 2 is essentially composed of two substantially similar, preferably direct-contact, heat exchangers 12, 14. Each of the heat exchangers includes a housing 16, 16'; a liquid reservoir 18, 18'; an evaporative media 20, 20'; a dripping chamber 22, 22' interposed between the reservoir and the evaporative media; liquid outlets 24, 24', e.g., nozzles or sprayers, and a fan 26, 26', located above outlets 24, 24'. The fans 26, 26' can be substituted by blowers (not shown), located at or adjacent to the fresh air inlet port 28 of heat exchanger 12 and air inlet port 28' connected to and receiving air from the space 10.

The liquid which can be used in the system, according to the present invention, can be with water, however, it is preferred to use a liquid desiccant and specifically brine. The following description will therefore relate to brine as a non-limiting example of a liquid.

Brine from reservoirs 18, 18' is selectively propelled by pumps 30, 30', through conduits 32, 32' to outlets 24, 24' of heat exchangers 12 and 14, respectively, as is clearly indicated by the arrows. Obviously, instead of the two pumps 30, 30', one pump

could be used. The reservoirs 18, 18' are interconnected by conduits 34, 34' to allow the flow of brine from one reservoir to the other, preferably by gravity. Optionally a control valve 36 is provided for controlling the flows between the reservoirs, as required.

Advantageously, system 2 also includes drift eliminators 38, 38', interposed between brine outlets 24, 24' and the fans 26, 26'. A humidifier 40 can also be installed in the passageway between heat exchanger 12 and the inlet 6 to space 10 within enclosure 4.

Referring now to Fig. 2, there is illustrated the system 2 of Fig. 1 adapted to improve enthalpy for ordinary summer operation. As seen, the system 2 also includes a heat pump 42, composed of an evaporator 44, a condenser 46, a refrigerant compressor 48 and an expansion valve 50, both interconnecting the evaporator 44 and condenser 46, for circulating the refrigerant in selected directions. Air from the outside is entered into the heat exchanger 12 and exchanges heat and vapor with the brine from reservoir 18' after passing through the evaporator 44 for further cooling before entering the enclosure 4. Thus, the fresh air entering the enclosure 4 is cooler and dryer.

Referring to Fig. 3, there is illustrated the system 2 of the present invention recommended to be used during non-extreme environmental conditions. The relatively cold air exiting from the cooled space 10 is utilized to cool the condenser 46 instead of heating the evaporator 44, as in the embodiment of Fig. 2.

During winter conditions when the outside air is colder than the air inside the enclosure, the system 2 of Fig. 4 can be used. The relatively warmer brine from reservoir 18' is propelled through the condenser 46 to receive extra heat before being utilized to heat the outside air in heat exchanger 12.

A further embodiment for winter heat conditioning is shown in Fig. 5. The evaporator 44 is relatively warmer than the condenser 46 due to the warmer brine from reservoir 18' passing therethrough. The compressor 48 operates efficiently because of the low pressure gradient between the evaporator 44 and the condenser 46. The latter

heats up the fresh air entering the heat exchanger 12 before being propelled into the enclosure 4.

With minor modifications, the system 2 can also be utilized for evaporation of industrial wastes. Seen in Fig. 6 is a system 2 according to the present invention, in which the reservoir 18 is provided with an inlet port 52 for adding brine to replenish evaporation, and reservoir 18' is fitted with an outlet port 54 for draining excess water.

While in the foregoing embodiments separate flow paths have been shown between each of the reservoirs 18, 18' and the heat pump 42, reference is made to Fig. 7 showing the system 2 in which a multi-way valve 56 is provided enabling controlling the flow from each of the reservoirs to the condenser or evaporator of the heat pump 42, for efficient air-conditioning during changing environmental temperatures.

In the preferred embodiments of the invention, it is envisioned to utilize as heat exchangers 12 and 14 the liquid/air direct contact heat exchanger of the type described in the publication WO 00/11426, the teachings of which are incorporated herein by reference.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrated embodiments and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

## CLAIMS

1. An air conditioning system for conditioning the space within an enclosure having at least one inlet and one outlet, said system comprising:
  - first and second liquid/air heat exchangers;
  - said first heat exchanger having an opening for receiving fresh air from the environment and for propelling the fresh air through said first heat exchanger to exchange heat with the liquid before it is entered into said enclosure, and
  - said second heat exchanger having an opening for receiving air from the enclosure and for propelling it through said second heat exchanger to exchange heat with the liquid before it is expelled into the atmosphere.
2. The system as claimed in claim 1, further comprising a heat pump, said first and second heat exchangers being in fluid communication with each other through said heat pump.
3. The system as claimed in claim 1, wherein each of said first and second heat exchangers comprising:
  - a housing having a liquid reservoir at its lower section and an evaporative media at its upper section;
  - a dripping chamber between said reservoir and said evaporative media;
  - liquid outlets disposed above said media;
  - means for forcing air to enter said housing and form a counter-flow relative to the liquid flow exiting from said liquid outlets, and
  - means for propelling brine from said reservoir to said liquid outlets.
4. The system as claimed in claim 2, wherein said heat pump comprising:
  - an evaporator;
  - a condenser, and
  - a refrigerant compressor and an expansion valve interconnecting said evaporator and said condenser.

5. The system as claimed in claim 4, wherein said heat pump further comprising means for reversing the flow of said refrigerant.
6. The system as claimed in claim 1, further comprising conduit means directly interconnecting said reservoirs.
7. The system as claimed in claim 1, wherein each of said reservoirs is in fluid communication with said heat pump via pump means.
8. The system as claimed in claim 4, wherein the outlet from said evaporator is in fluid communication with the liquid outlets of said second heat exchanger and the reservoir of said second heat exchanger is in fluid communication with the liquid outlets of said first heat exchanger.
9. The system as claimed in claim 7, further comprising a multi-way valve operationally connected between said reservoirs and said heat pump.
10. The system as claimed in claim 7, wherein the reservoir of said first heat exchanger is in fluid communication with said evaporator and the reservoir of said second heat exchanger is in fluid communication with said condenser.
11. The system as claimed in claim 7, wherein the reservoir of said first heat exchanger is in fluid communication with said condenser and the reservoir of said second heat exchanger is in fluid communication with said evaporator.
12. The system as claimed in claim 3, wherein said means for forcing air into said housing is a fan located above said liquid outlets.
13. The system as claimed in claim 12, further comprising a drift eliminator located between said liquid outlets and said fan.
14. The system as claimed in claim 1, further comprising a humidifier disposed in the passageway leading from said first heat exchanger to said enclosure.
15. The system as claimed in claim 3, wherein one of said reservoirs further comprises an inlet port for adding liquid to replenish evaporation and a second of said reservoirs comprises an outlet port for draining excess liquid.
16. The system as claimed in claim 1, wherein said liquid is a liquid desiccant.



17. The system as claimed in claim 1, wherein said liquid is brine.
18. A method for air-conditioning an enclosed space, comprising:  
providing an air-conditioning system as claimed in claim 1, and  
precooling said liquid prior to entering same into the evaporator by utilizing cooled air from said space.
19. A method for air-conditioning an enclosed space, comprising:  
providing an air-conditioning system as claimed in claim 4, and  
utilizing the heat pump for preconditioning the liquid passing therethrough before propelling the liquid through said heat exchangers.
20. The method as claimed in claim 19, comprising extracting heat from said condensor by cooling liquid passing therethrough with cooled air.
21. The method as claimed in claim 19, comprising preheating liquid in said condensor by exchanging heat between liquid and heated air.
22. The method as claimed in claim 12, comprising heating the evaporator by liquid heated by exchanging heat between said liquid and heated air.
23. A method for evaporation of industrial wastes, comprising:  
providing a system as claimed in claim 15;  
replenishing the reservoir of the heat exchanger receiving fresh air from the environment with liquid desiccant, and  
draining excess water from the reservoir of the other heat exchanger.

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Fig.1.

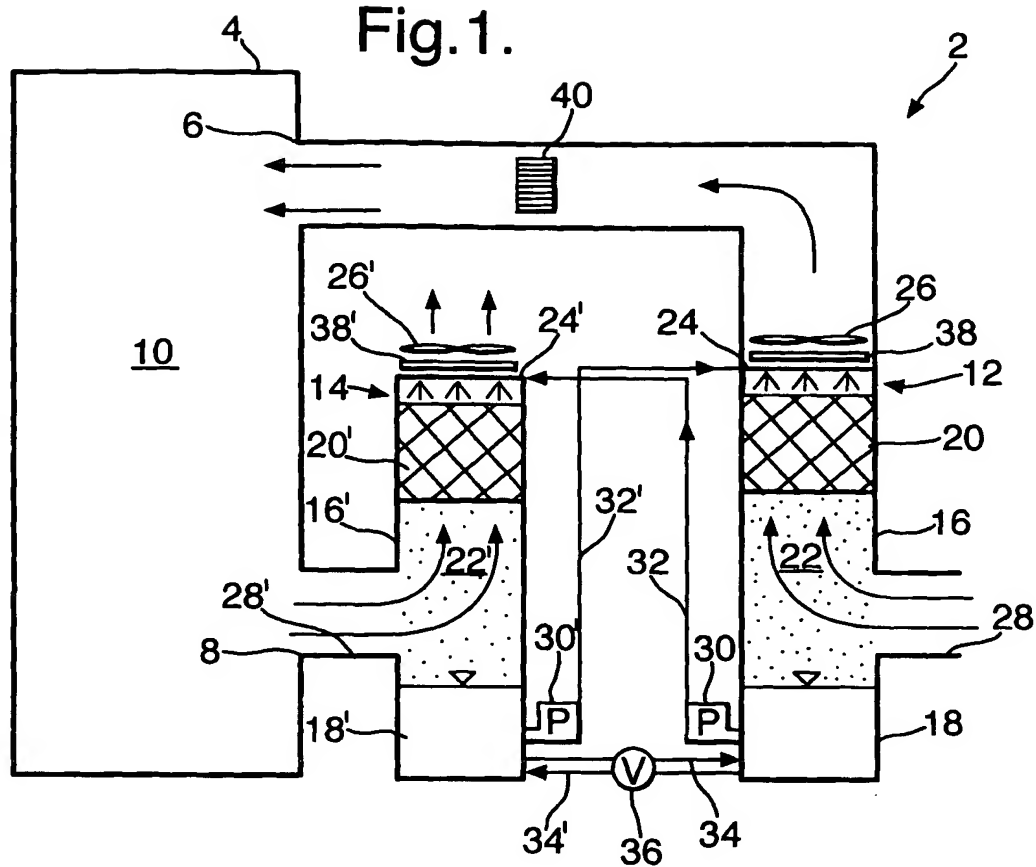
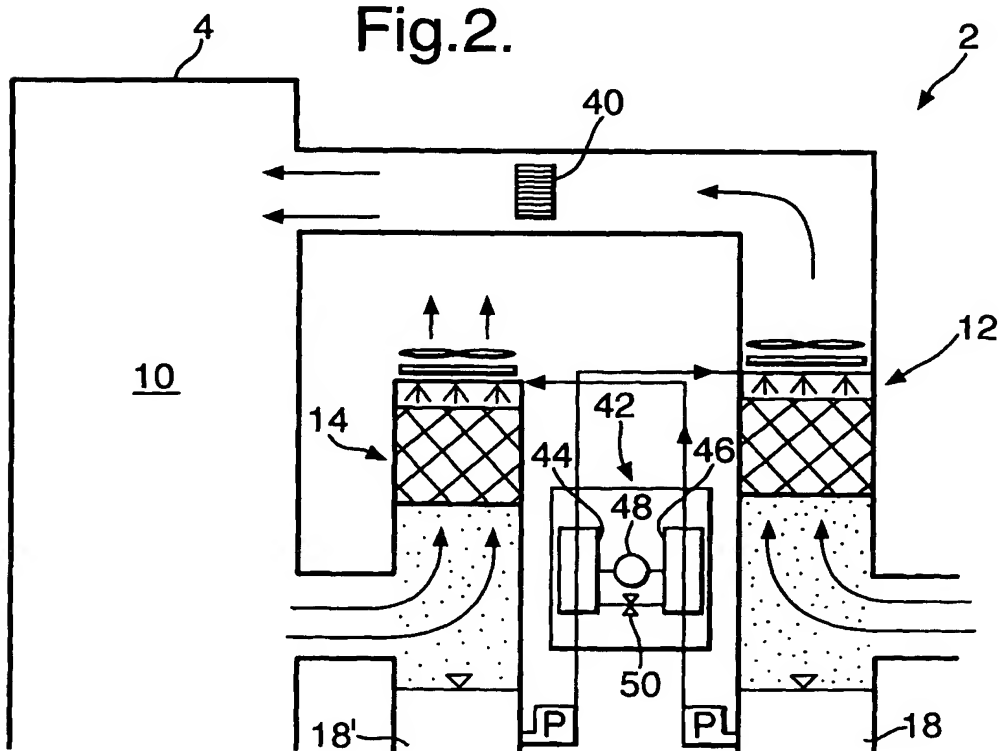


Fig.2.





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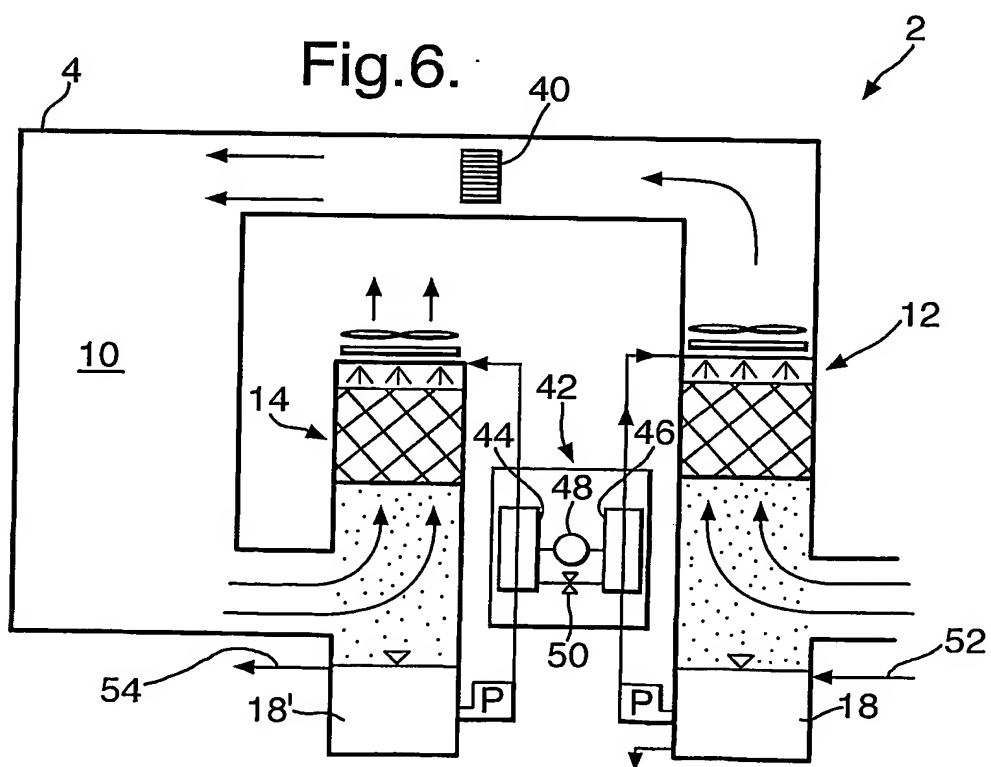
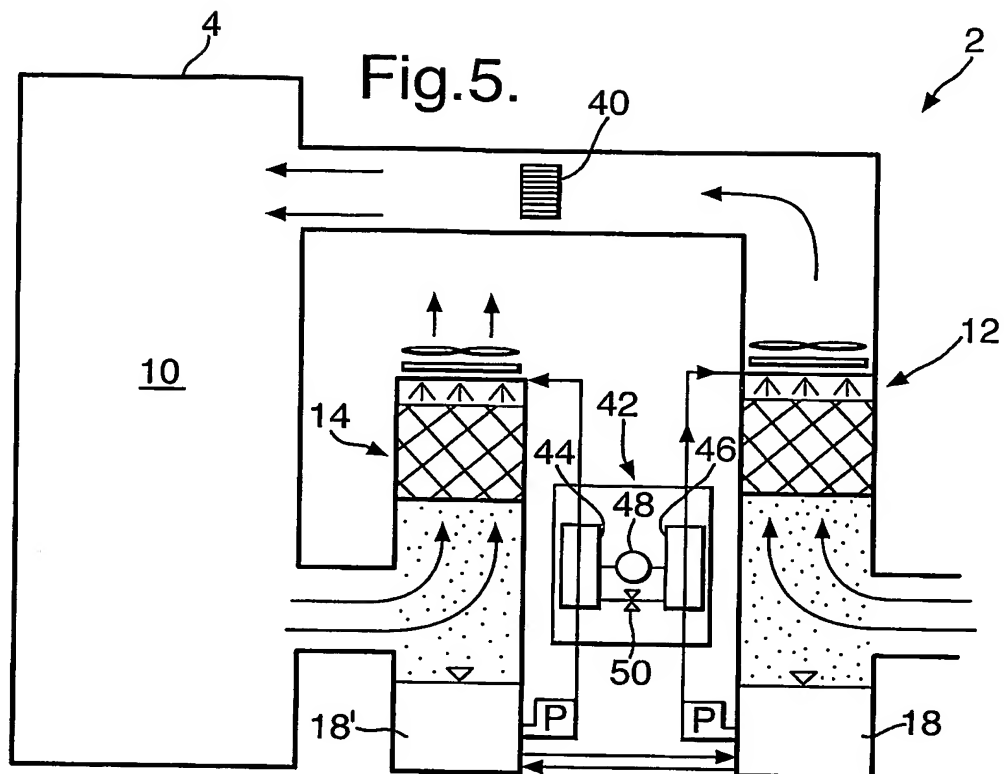
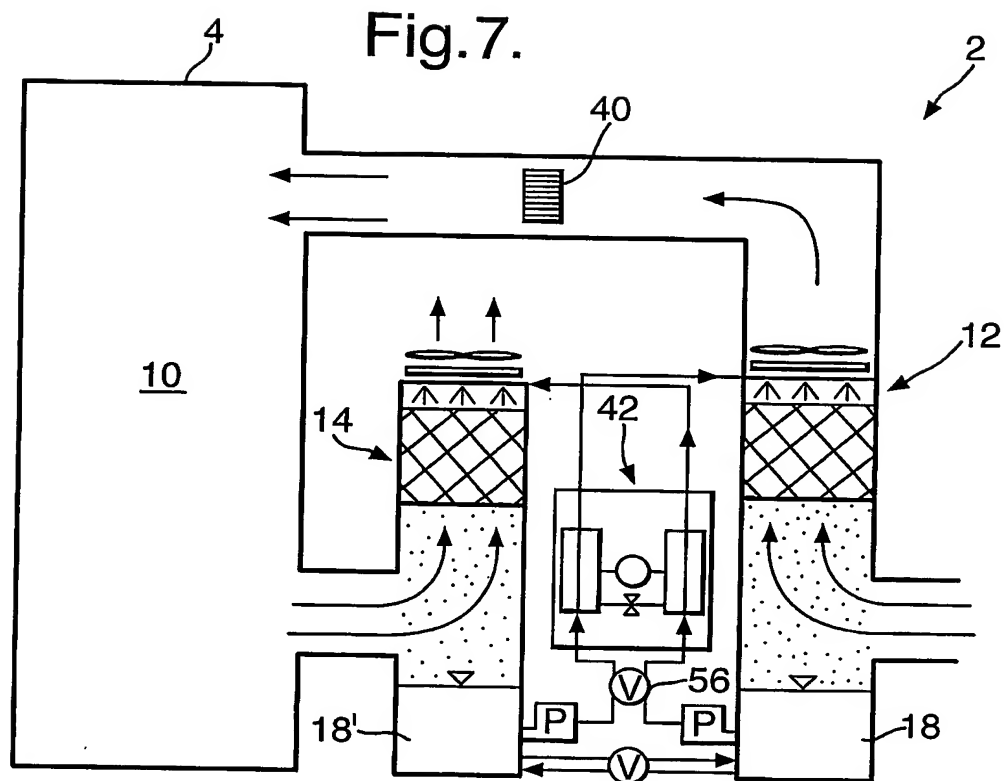


Fig. 7.



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/03/00943

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 F24F3/14 F24F5/00 F25B30/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F24F F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 018 954 A (ASSAF GAD) 1 February 2000 (2000-02-01) the whole document	1-8, 10, 11, 15-22
X	US 4 941 324 A (HOWELL JOHN R ET AL) 17 July 1990 (1990-07-17) the whole document	1-4, 6-8, 14-18
X	US 3 712 026 A (DANKO E ET AL) 23 January 1973 (1973-01-23)  the whole document	1, 3, 6, 12, 13, 16-18
X	FR 1 278 153 A (MAITRE HENRI) 8 December 1961 (1961-12-08) abstract; figures 1, 2	1, 3, 6, 16-18
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

1 March 2004

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## INTERNATIONAL SEARCH REPORT

International Application No

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 420 993 A (KELLEY GILBERT A) 20 May 1947 (1947-05-20) the whole document ----	1, 3, 12, 16-18
X	US 6 266 975 B1 (ASSAF GAD) 31 July 2001 (2001-07-31) abstract; figure 1 ----	1, 3, 16-18
X	US 2 162 158 A (CLARK COEY STEWART) 13 June 1939 (1939-06-13) abstract; figure 3 -----	1

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-17, 18

Air conditioning system (claims 1-17) and method (claim 18) for conditioning an enclosure, wherein the system is provided with liquid/air heat exchangers (20, 20') and the method comprises the step of precooling said liquid by utilizing cooled air from said enclosure prior entering the same into the evaporator (20').

2. Claims: 1-17, 19-22

Air conditioning system (claims 1-17) and method (claims 19-22) for conditioning an enclosure, wherein the system is provided with liquid/air heat exchangers (20, 20') and with an heat pump (42), and the method comprises the step of utilizing the heat pump (42) for preconditioning the liquid passing therethrough before propelling the liquid through said heat exchangers (20, 20').

3. Claims: 1-17, 23

Air conditioning system (claims 1-17) and method (claim 23) for the evaporation of industrial wastes, wherein the system is provided with liquid/air heat exchangers (20, 20') and liquid reservoirs (18, 18') provided with liquid outlets (54), and the method comprises the step of replenishing the reservoir of the heat exchanger (20) with liquid dessicant and draining excess water from the reservoir of heat exchanger (20').



# INTERNATIONAL SEARCH REPORT

International application No.  
T/IL 03/00943

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
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2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
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## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

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see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
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### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/03/00943

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 6018954	A	01-02-2000	IL 113446 A AT 246787 T AU 5539996 A CN 1182475 A DE 69629368 D1 EP 0824659 A1 JP 11504105 T WO 9633378 A1	05-04-1998 15-08-2003 07-11-1996 20-05-1998 11-09-2003 25-02-1998 06-04-1999 24-10-1996
US 4941324	A	17-07-1990	US 4984434 A	15-01-1991
US 3712026	A	23-01-1973	AU 3356471 A CA 948100 A1 DE 2144171 A1 FR 2113382 A5 GB 1318829 A JP 57007326 B NL 7115223 A ,B,	22-03-1973 28-05-1974 10-05-1972 23-06-1972 31-05-1973 10-02-1982 08-05-1972
FR 1278153	A	08-12-1961	NONE	
US 2420993	A	20-05-1947	NONE	
US 6266975	B1	31-07-2001	IL 122065 A AT 241116 T AU 738856 B2 AU 9642598 A CN 1128966 B DE 69814899 D1 EP 1027562 A1 WO 9922180 A1 JP 2001521136 T	06-12-2000 15-06-2003 27-09-2001 17-05-1999 26-11-2003 26-06-2003 16-08-2000 06-05-1999 06-11-2001
US 2162158	A	13-06-1939	NONE	

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